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Supporting Information for

Title First Evidence of Middle Atmospheric HO2 Response to 27-day Solar Cycles From Satellite Observations

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Additional Supporting Information (Files uploaded separately)

Introduction

In the supporting materials, we include Figure S1 to show the cross correlation between the time series of MLS HO_2 observations and solar Lyman-α at each pressure level shown in Figure 4. Figure S2 shows the 1-to-1 scatter plots and linear regression results for data shown Figure 4. The results in Figure S2 are summarized into a vertical profile plot in Figure 5 in the main manuscript.

To compare our analysis results for data during 2012 – 2015 around the peak of Solar Cycle 24 (Figure 5), we also include Figure S3 here to show the analysis results for data during 2004 – 2005. Compared to results around the solar peak, the weaker correlations between HO_2 variability and solar Lyman-α variability during 2004 – 2005 is consistent with the weaker solar activity during the declining phase of Solar Cycle 23.

To compare our analysis method with the band-pass filter method used in previous studies [*Shapiro et al., 2012*], we include Table S1 to show the linear correlation results from both methods. The latter generally produces larger correlation slopes but with larger error bars and weaker correlation coefficients, showing the advantages of our analysis method for this type of subtle signal extraction.

The global mean offline HO_2 data (55S-55N) during 2012-2015 that was used in this study is also included in the supporting materials as Dataset S1. The complete zonal mean offline HO_2 data will be made publically available by the Aura MLS team in early 2016. Anyone interested can register as a user at MLS's website or contact the MLS team to get access to the data.

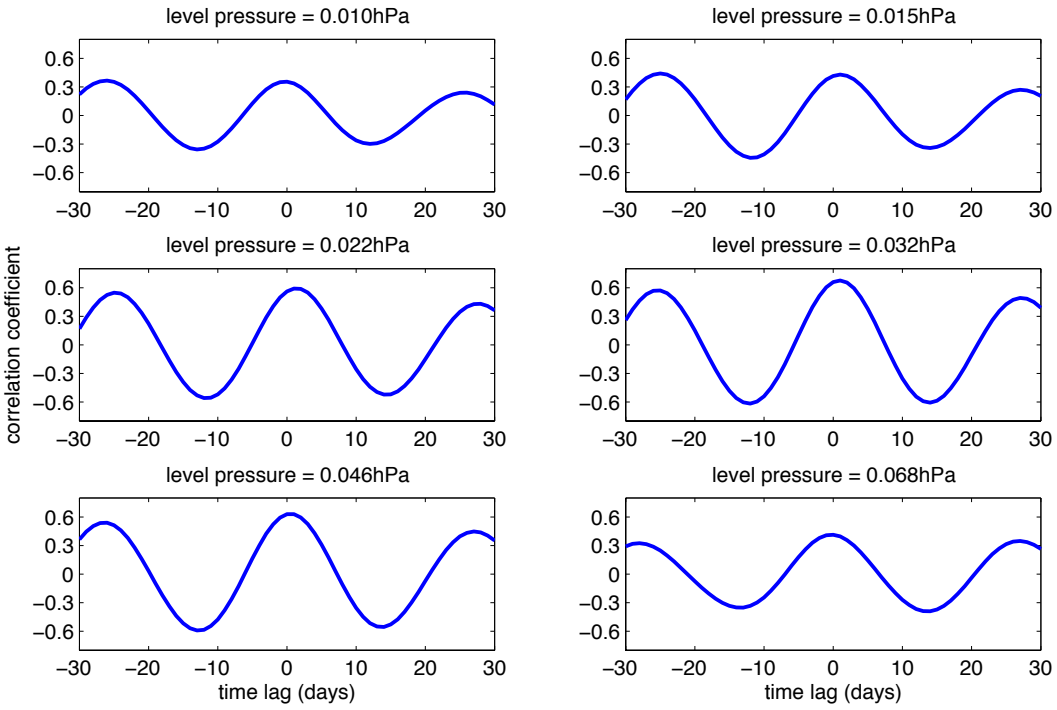

Figure S1. Cross correlation between solar 27-day cycle variability signals in MLS HO_2 and solar Lyman-α at 6 pressure levels in the mesosphere. The time series plots of these scatter values are shown in Figure 4. HO_2 is clearly shown to follow solar Lyman-α variability during the 27-day cycles with no time lag.

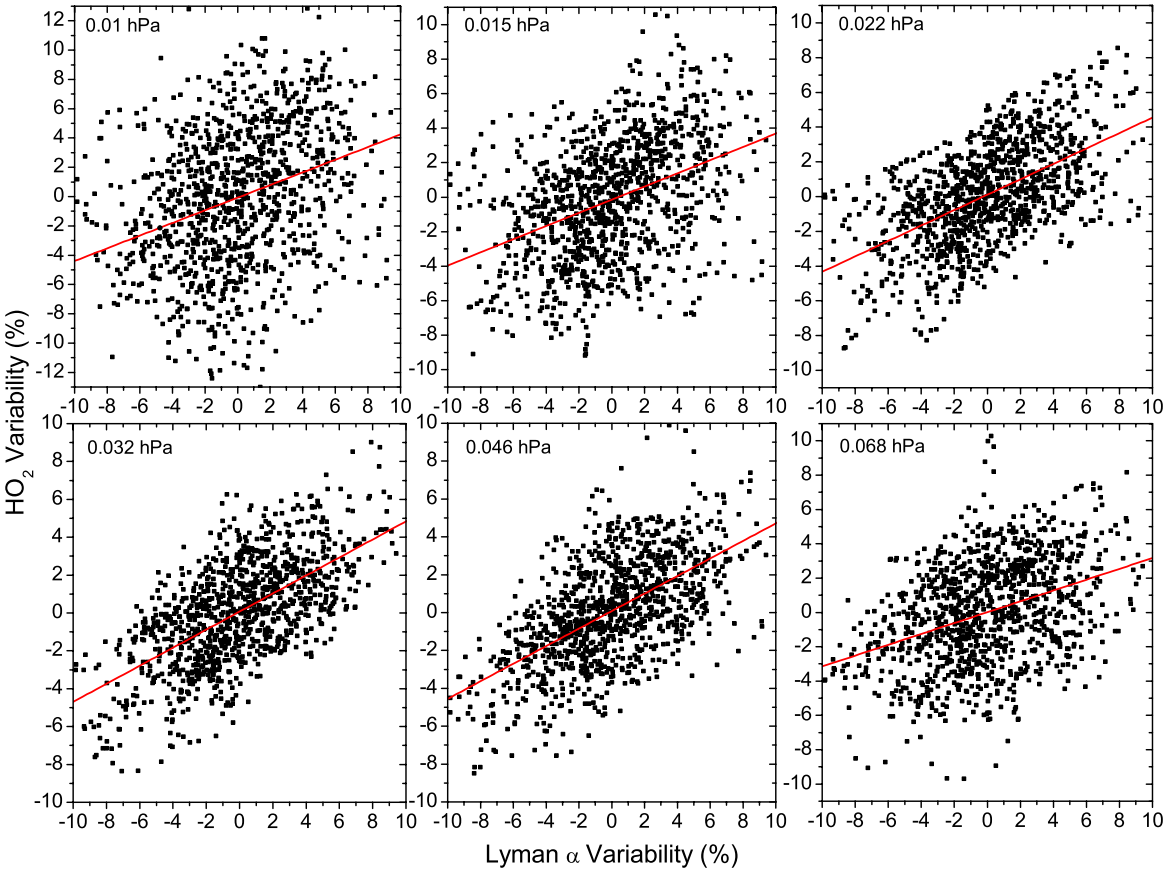

Figure S2. Linear correlation between solar 27-day cycle variability signals in MLS HO_2 and solar Lyman-α at 6 pressure levels in the mesosphere. The time series plots of these scatter values are shown in Figure 4. The liner fit slopes, fit uncertainties, and correlation coefficients R^2 are summarized in Table S1 and illustrated in Figure 5.

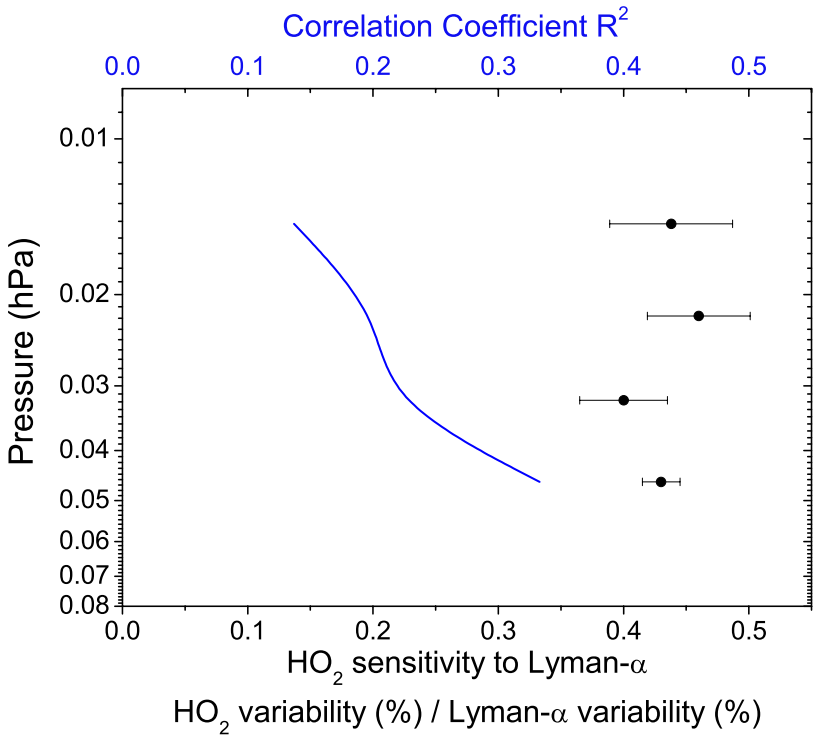

Figure S3. Vertical profile of the magnitude of the MLS HO_2 response to solar Lyman-α variability for the data during September 1, 2004 – December 31, 2005. The x-value is the slope of the linear fit between HO_2 variability and Lyman-α variability. Error bars represent the uncertainty in the linear fit. The correlation coefficient R^2 is plotted in blue and also reflected in the size of the symbols. The correlations are clearly weaker than those in Figure 5 for data during 2012 –2015.

Pressure (hPa)	Our analysis		Band-pass filter	
	Slope	R^2	Slope	R^2
0.01	0.43±0.04	0.11	0.48±0.04	0.14
0.015	0.38±0.02	0.19	0.42±0.03	0.16
0.022	0.44±0.02	0.35	0.46±0.03	0.21
0.032	0.48±0.02	0.44	0.52±0.03	0.24
0.046	0.46±0.02	0.40	0.50±0.03	0.23
0.068	0.32±0.02	0.16	0.30±0.03	0.12

Table S1. Summary of the linear correlations (slopes with fit uncertainties, and correlation coefficients R^2) between extracted HO_2 variability and Lyman-α variability. "Our analysis" method is described in this manuscript and the results are shown in Figures S1 and 5. "Band-pass filter" method refers to the 20-35day filter used in Shapiro et al., [2012].

Data Set S1. MLS global mean HO_2 data used in this study. Number density data during 2012-2015 at 6 pressure levels in the mesosphere is included in the data file.